Heterogeneous microstructures and macroscopic creep behavior of polycrystalline ice (*)

Ricardo A. Lebensohn

Materials Science and Technology Division, Los Alamos National Laboratory, Los Alamos, NM 87544, USA.

We present results of two complementary formulations, a full-field approach based on fast Fourier transforms (FFT) [1] and a mean-field approach based on rigorous nonlinear homogenization [2] to study the influence of different microstructural features on the macroscopic behavior of polycrystalline ice. The FFT-based model is used for the prediction of local fields in columnar ice polycrystals deforming in compression by dislocation creep [3]. The predicted intragranular mechanical fields are in qualitative good agreement with experimental observations, in particular those involving the formation of shear and kink bands. These localization bands are associated with the large internal stresses that develop during creep in such anisotropic material, and their location, intensity, morphology and extension are found to depend strongly on the crystallographic orientation of the grains and on their interaction with neighbor crystals. In turn, this numerically-intensive full-field formulation is used to validate the predictions of different, more efficient homogenization approaches. We show that a recent second-order formulation, which explicitly uses information on average intragranular field fluctuations, implemented within the widely used ViscoPlastic Self-Consistent (VPSC) code [4], yields the most accurate results.

[1] H. Moulinec and P. Suquet, Comput. Methods Appl. Mech. Eng. 157, 69 (1998).
[2] P. Ponte Castañeda, J. Mech. Phys. Solids 50, 737 (2002).
[3] R.A. Lebensohn, M. Montagnat, P. Mansuy et al. Acta Mater. 57, 1405, (2009).
[4] R.A. Lebensohn, C.N. Tomé and P. Ponte Castañeda. Phil. Mag. 87, 4287 (2007).

(*) Invited Lecture, Session C22: "Mechanical Constitutive Behavior of Ice-Containing Materials". AGU 20009 Fall Meeting, 14–18 December, San Francisco, CA, USA.